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ON POISONS AND DISEASE AND SOME EXPERIMENTS WITH THE TOXIN OF THE BACILLUS TETANI[1, 2]

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SECTION N of our association has, as you are aware, the very wide field of the medical sciences for its subject-matter, and it seems appropriate for a member of that section to address you on a subject which, while a primary concern of medicine and biology, is yet not without interest to scientists in general. I am therefore presenting to-night some considerations on poisons and disease.

Many of us who are not students of the medical sciences are but little interested in theories of disease. When illness overtakes us we wish to be cured "safely, quickly and pleasantly." There lived in the first century B.C. in Rome a Greek, a very successful and learned physician who was also a writer and philosopher, who promised his patients to cure their diseases according to that excellent and oft-quoted formula, *"Curare tuto, celeriter et jucunde."* We may be sure that this Greek scholar, the friend of the great writers and statesmen of his day, was a bit of a humbug as a physician, for only the God of healing himself could always make such a promise good. Nevertheless, the physicians of our day frequently succeed in curing certain diseases in accordance with this happy formula, but their greatest achievement in modern times is the prevention of disease.

[1] Address of the president of the American Association for the Advancement of Science, Boston, December 27, 1933.

[2] A grant from the Carnegie Corporation of New York enabled my coworkers and myself to carry out the experimental work described in the second part of this address.

Medicine in its cruder forms was no doubt, next to food, clothing and shelter, one of the earliest concerns of primitive man. He must soon have learned that certain bulbs, roots, seeds, berries, leaves and other parts of plants could not be eaten without fatal results; and he also soon learned that the bites of venomous serpents led to a more or less rapid death, and that there were numerous poisonous insects and grubs, poisonous fish, and other creatures on land and in the waters that had to be guarded against and many of which could not be eaten with impunity. We may be certain also that primitive man very early acquired a knowledge of how poisons that destroyed him could be utilized in the chase to bring down large and dangerous animals that were used by him for food and other purposes. The removal of venom from the poison sacs or the crushed head of a deadly snake and its application to the head of an arrow or a spear is an act that requires only the most elementary degree of mental acumen. As far as we know, every race of man in its early stages made use of arrow poisons, and the practise still prevails among uncivilized peoples to-day. The number of poisons that have been and are still used for this purpose, according to students of the subject, probably runs into the hundreds. We know that poisons suitable for this purpose are found in large number among plant products and in innumerable forms of animal life from the lowest to the highest. They range in fact from the most nauseating of odoriferous, volatile, but often only relatively harmful compounds to the most lethal of the fixed venoms and toxins. The invention of smearing arrows, spear heads and other weapons with poisons was certainly of the highest utility for primitive man in the chase, as it enabled him to kill the largest and most dangerous animals with the least amount of danger to himself. The antiquity of the invention can be traced back to a very early stage in man's history, and it is probably the first example of a physiological or pharmacological experiment made by him. The experimental pharmacology, the surgery and medicine of primitive man were early burdened with a belief in the supernatural causes of disease, and such rational experimentation as there was gave place to "a nightmare of evil spirits," magic and sorcery and a reliance on enchantments, as is still the custom in our day among backward peoples. Stinging insects and venomous serpents were no doubt the first among animal forms to invent hypodermic injection, a procedure which was introduced into medical practise only in the years 1845 to 1856. The venoms of stinging insects and deadly serpents are products of their own metabolism, formed in special glands, but it must not be thought that they have been developed in the long course of time solely for self-protection. It is well known to workers in institutes devoted to the preparation of antivenins that the venom is indispensable to the serpent for the maintenance of its health. The poison can not be expressed from the glands during the period of sloughing the skin or too soon after ingestion of food without fatal results to the reptiles. The venoms, therefore, play an essential rôle in the internal economy of these creatures, perhaps quite aside from the fact that they contain proteolytic ferments essential for digestion. Similarly, the poisons of bees and wasps appear to aid in the development of their eggs, after they have been fixed on them.

The mortality due to venomous snakes and stinging insects is a trifling matter compared with that due to the biting insects. These also introduce beneath the skin small amounts of irritating substances, that are of negligible importance in comparison with the extrinsic or adventitious agents that may be introduced into the bite at the same time. The biting insects, such as certain kinds of mosquitoes, fleas, the tsetse fly, the African horse fly, the body louse, or "cootie," and various ticks, are responsible for the great scourges that have decimated mankind and destroyed his domestic animals. Their responsibility is, however, of an indirect character, as they merely happen to be the carriers of deadly varieties of microorganisms. Among the serious diseases due to biting insects are malaria, yellow fever, black death, or bubonic plague, African sleeping sickness of man and the allied diseases of domestic animals, typhus fever and many more.

The elucidation of the causes of these and other infectious diseases, the development of specific curative agents for some of them and methods for their eradication and prevention are among the great achievements of the biological and medical sciences during the past sixty years. Only the most highly civilized and wealthy nations of the world are in a position to suppress more or less completely the dreaded insect-borne diseases of which I have been speaking. Malaria is one of them that can be completely eradicated, and yet Professor Bass writes of this disease as follows: "Unfortunately the outlook is not so favorable for the less civilized and less fortunately situated people of the world. The proportion of the people in many countries who have the disease varies from none in some countries to practically 100 per cent. in others. Even now millions, yes, more than a hundred million people throughout the world, suffer with it every year and more than a million die."

Among the remains in caves of the Madelenian epoch in the Vézère, the Dordogne and elsewhere in France are found the bones of human beings and those of many large animals, as the bear, the aurochs, mammoth, reindeer and others of that time. The man of this period fashioned for himself from bones spear

points, harpoons, hooks, needles and other implements, and carved pictures, on bones, reindeer antlers and teeth, of many of the animals of his time, and there is at least one considerable work of his art that "depicts trees, horses and an aurochs, and a snake biting a man's leg." In this remote period of antiquity the serpent, as ever since, "bruised the heel of man." What is of especial interest to us is the fact that the spear heads and harpoons of the man of that epoch had a series of pits on them or a series of parallel grooves, which some archeologists believe were designed to hold deadly poisons. It is apparent that such poisoned weapons were also effective in warfare, and this use of poisoned spears and arrows by primitive man against his human enemies has never been forgotten. South American Indians invented "poison gas" long ago, according to Baron Nordenskiöld, who says: "The Indians of (South) America cultivate a spice plant, Spanish pepper (Cayenne pepper), which is of the greatest importance to them. They have discovered that by the burning of this pepper there is developed a sort of "poison gas" that proves effective in laying siege to villages fortified by palisades." The Romans in their wars with the Gauls and Germans and other peoples in the early centuries of our era lost many of their men from wounds made by poisoned arrows—wounds that were of no significance of themselves. L. Lewin, an investigator and historian in this field of study, has gathered references from the literature that prove that the French, Swiss and Spaniards continued to employ poisoned weapons in hunting deer and the wild boar down to the fourteenth and even to the latter part of the sixteenth century, particularly in Spain. Some historian has said that war has been the chief industry of man throughout the ages and promises to continue to be so for many a long day. Certainly in our day war and preparations for war must still be counted among the greatest of our industries. At the moment chemists in the employ of governments everywhere throughout the world are busier than ever in inventing lethal gases, fluids and even relatively insoluble toxic substances for the destruction of the enemy's forces and, unavoidably at times, of his civilians.

We have mentioned arrow poisons that are secreted by the poison glands of venomous serpents. Such poisons are generally spoken of as venoms and sometimes as toxins, but it will be seen later that the latter term is generally applied in our day to the deadly poisons elaborated by pathogenic microorganisms. It is interesting to note that our words *toxic, toxin,* in*tox*-icate, and the large number of combining forms and derivatives so widely employed in the biological sciences contain the root or stem of the Greek word for bow—τοξον—often used in the plural for arrows. The poison for smearing arrows was originally termed τοξικον φαρμακον, but in the course of time the noun of the phrase was dropped and the adjective form, τοξικον, "of, or pertaining to the bow," took on the significance, "poison for arrows," and then of poison in general. The literature of the ancients, as well as our own and that of other nations and their folk-lore, contain numerous figurative expressions based on this ancient use of poisoned weapons. Job mourns, "For the arrows of the Almighty are within me, the poison whereof drinketh up my spirit." Stockman, in writing of arrow poisons, after speaking of the widespread belief that malignant disease or pestilence is due to the invisible but deadly arrows of the offended gods, remarks "that even such an impalpable feeling as love was conveyed into the heart by means of Cupid's darts."

Many of you practise archery in your vacations, as a pastime or as an aid to health, and you may possibly know that the English scholar and man of letters, Roger Ascham, Latin secretary to Queens Mary and Elizabeth and the author of that well-known treatise entitled "The Scholemaster," wrote a book on archery in 1545, which he called, "Toxophilus," or Lover of the Bow. The treatise is in the form of a Socratic dialogue between Toxophilus, who defends the use of the bow as an indispensable national weapon and also as a means of dispelling the "grosse and colde humours" that "gather and vexe scholers," and Philologus, who has to be convinced of the advantages derived from "shoting." The little work is no longer read in our day, but is full of classical learning and reflections on a variety of subjects touching the physical and moral health of men and nations. Through it the word "toxopholite" was introduced into the language, to designate the devotee of archery, and in England there was even a "Toxopholite Society" in the eighteenth century.

We have been speaking of the silently operating and, to primitive man, mysterious and deadly agents that are found so widely distributed in nature and that are usually designated as poisons, and we may ask, What is poison?

What Is Poison?

Let me say to begin with that no one has ever been able to give a concise and accurate definition of a poison that would apply to every one of the many thousands of known poisons. All attempts to do this have simply ended in offering definitions that do not define. The medical jurisprudence of this country and of England has never attempted to define the word *poison.*

The exponents of the medical and biological sciences are, however, no worse off in respect to the impossibility of defining in a satisfactory manner such

terms as *living* or *life, disease* and *health,* than are the exponents of the other natural sciences in defining certain of their fundamental concepts.

Nature has not affixed a poison label to any particular substance or class of substances. The pharmacist does that. I have met intelligent people who actually believe that once a poison always a poison, and that it continues to exert its noxious power in some degree to the last molecule. If ten milligrams of nitrate of strychnine be dissolved in five hundred cubic centimeters of sterilized physiological saline solution, each cubic centimeter will contain 0.02 mg of the strychnine salt, but no one in the world could demonstrate either a harmful or a beneficial action after the injection of a half or one cubic centimeter of this solution underneath a person's skin or when so small a quantity as this is taken by mouth. We can, however, still detect the bitter taste of this highly diluted strychnine solution if we hold a cubic centimeter of it in the mouth for a few seconds, and if a wine-glassful were swallowed a mild stimulation of the digestive apparatus might or might not occur. The experience of physicians throughout the ages has convinced them that even the most deadly of poisons are entirely innocuous when given in certain minimal quantities. Scientists have arrived at the same conclusion on the basis of their experimental work. To be quite accurate, however, we can only say that neither a harmful nor a beneficial influence can be detected after such minimal doses by *any methods known to us at present.*

There is, however, another fact of fundamental importance for everything that is endowed with life, whether it be a plant or an animal or something that lies somewhere between the two. This fact may be expressed as follows: The harmful effects of a large dose of a drug or a poison do not fall off *pari passu* with the diminution in dose. The law of concomitant variation in respect to the two variables does not hold for the living cell. On the contrary, with the diminishing dose there may occur a turn-about in the action of the drug with the appearance of a highly beneficial action, one indeed that is indispensable for the continuance and maintenance of health, as is the case when we pass from the toxic dose of a hormone to its therapeutic dose. Examples of this beneficial action are seen daily in medical practise. Many powerfully acting drugs, to which the popular designation of poison is entirely applicable, such as strychnine, quinine, the digitalis glucosides, certain arsenicals, insulin, parathyroid extracts, the vitamins, and a long list of other drugs illustrate this principle when their dosage is restricted to a certain amount. This fact holds also for other agents of our environment that may be very harmful in their action when they come in contact with our tissues in too high a concentration. Sunlight and other forms of radiation are instances in point. In ordinary concentrations sunlight is beneficial, but it is deadly in its effect on many organisms when they are exposed to it for too long a time. Its scorching action on the skin of adults at high altitudes and in the tropics is well known, and it is also well known that very young children have died as a result of exposure for too long a time to the burning rays of the noonday sun without having been previously inured to its action.

Poisons in Our Bodies

An excellent illustration of our principle that toxic substances may be highly beneficial and even indispensable to life is furnished by certain poisons that are produced in our own bodies and circulate in our blood, at a concentration below the toxic level. Many will be surprised to learn that we ourselves are walking drug shops, and that an experienced chemist or pharmacologist would have no difficulty in preparing arrow poisons from some of our own organs that would have delighted the heart of primitive man. Let me name only a few of these autogenous poisons that serve not only to maintain our normal state of health but are also indispensable for the alleviation or removal of the symptoms of grave metabolic disorders—insulin, a hormone manufactured in certain cells of the pancreas, is one of them. It is known to all of you that when the concentration of this hormone in the blood falls below a certain level for any length of time, a serious disease known as diabetes mellitus inevitably appears. Our bodies probably require for the maintenance of health that the pancreas should produce and pass into the blood during each 24 hours about eight milligrams of this substance, and when, as I have just said, this amount is no longer furnished by the pancreas, diabetes results. You are also well aware of the fact that the subcutaneous administration of insulin as manufactured from the pancreas of beeves causes an immediate and spectacular improvement in the diabetic patient. As long as the deficiency of insulin persists, the patient must have his daily injections of the insulin from animal sources. During the first years of this so-called replacement therapy, it was occasionally observed that children fell into convulsions after the administration of an overdose of insulin. This extraordinary effect is daily seen in the laboratories in which insulin is being standardized for medical practise by testing it out on rabbits that have been previously kept without food for 24 hours. After a certain dose these animals fall into the most violent epileptiform convulsions, which generally end fatally if nothing is done, but which can be immediately and entirely dispelled by the intravenous injection of a little glucose. After the injection of this antidote the animal is immedi-

ately restored to perfect health. A similar treatment was applied to children that had been given too much of the drug. It is the function of this hormone to supervise and control, so to speak, the metabolism of carbohydrates in our tissues, and it is especially toxic in overdose for those animals or human beings the sugar content of whose blood happens to be low at the time of its administration for curative purposes. No experimentalist can doubt that an intravenous injection of 20 or 30 mgm of this hormone would suffice to kill a person of average weight who has gone without food for a couple of days. It is well known to physicians that under certain circumstances, as when a tumerous growth invades the hormone-producing organ, or even without this cause, an excessive amount of the hormone is produced and distributed in the body. In such instances serious impairment of health and death may occur. Fortunately, indeed, we are not often poisoned in this manner. In one recently reported instance a year-old child had repeated epileptiform convulsions, with retarded mental development and only about half of the normal amount of sugar in the blood, in consequence of an overproduction of insulin in its pancreas. Removal of a large part of the overactive pancreas caused the child's condition to return to the normal state. Cases of this nature have also been seen in adults, and here also an operative procedure was followed in some instances by an improvement in health. Conditions of this type, in which the causative agent is produced in insufficient amount or in excess in our own bodies, are spoken of as diseases of endogenous origin. Another, and one of the most striking instances of overproduction of a hormone, is seen when the very small parathyroid glands, four or more in number, which lie close to the thyroid gland in the neck or are embedded in it, are stimulated for one reason or another to produce their hormone in excessive amounts. Calcium is then removed from the bones to such a degree that they can no longer bear the weight of the body. The individual becomes bedridden, his muscles atrophy, other consequences follow, and he dies unless he can be rescued by the removal of one or more of these very small but diseased glands. There are still other toxic hormones, some of which circulate in the body in much smaller concentration than insulin. Among them is adrenalin, or the epinephrin of our pharmacopœia. An intravenous injection of this much used and therapeutically valuable drug is fatal to animals and human beings in doses that are not so very large and furnish definite proof of its inherent toxicity. Unfortunately, also, a number of deaths have occurred from its unwise use or from overdosage. Such accidents appear to be inevitable now and then in the use of drugs in general. As I have said, this is one of the hormones, as distinguished from insulin, of which the body appears to need under normal conditions only a very small amount in each unit of time. Its concentration in the blood, which, by the way, is sufficient for the body's ordinary needs, is minute and is represented by the astonishingly small number of 10^{-8}. It is endowed with extraordinary ability to constrict tiny blood vessels and is of the greatest service in medicine for this reason. And those who suffer from bronchial asthma obtain almost instantaneous relief from their spasmodic labored breathing after subcutaneous administration of a small amount of the hormone. But even in these patients toxic effects have been noted after a very prolonged use of the drug in too large a dose. Death has occurred from too rapid intravenous injection of one or more milligrams in the case of persons suffering from one of the thyroid diseases, and it is estimated that 10 mgm, or about one sixth of a grain, when intravenously injected, would kill a human being of average weight. I need not multiply instances of the deadly effects of excessive amounts of these peculiar principles that are so indispensable to the maintenance of health when they circulate in the body in an appropriate concentration.

It is not otherwise with the vitamins, which may be called hormones of plant origin and which are equally indispensable to the maintenance of health. One of these, irradiated ergosterol, or vitamin D, has been shown to induce very marked pathological and chemical alterations in the tissues of experimental animals, which finally lead to the death of the animals after too prolonged a medication with this principle, and there is already a considerable literature on the harmful effects of overdosage or of too prolonged an administration of this vitamin D to very young children. Fortunately, in most of these instances, the harmful symptoms disappeared after the vitamin was withdrawn. It would appear that with this drug what is called in medicine, the *dosis therapeutica* soon passes into the *dosis toxica*. Very recently a pathological state called *hypervitaminosis A* has been described as occurring in young rats that have received excessive doses of vitamin A. The disease is characterized by a faulty nutrition of the skin, inflammation of the eyes, spastic contractures of the extremities and cessation of growth, all of which pathological alterations may lead to the death of the animal. Early discontinuance of the overdosage is followed by disappearance of these symptoms and resumption of growth. It is thought that this disease is not likely to occur in human beings, as they would probably not receive such very large doses of the vitamins as were given to rats.

I have spoken to you of hormones and vitamins to show how difficult it is to define the word "poison." From the wider biological view we should not think

of poisons as being inherently more malevolent than any of the other agents or influences of our environment to which we are constantly exposed. I incline to the belief that no living cell exists whose contents or metabolites are not toxic to some other living cell; in other words, all cells are in reality cryptotoxic systems.

WHAT IS DISEASE?

Death hath a thousand doors to let out
life, . . .—*Massinger: A Very Woman.*

The late Sir Clifford Allbutt, the distinguished regius professor of medicine of the University of Cambridge, has said, "Disease is the correlative of health and is incapable of a more penetrating definition." So also we find it difficult to define health in a concise sentence or two. People speak of one as being in good health, or in bad health, or that he enjoys only a moderate degree of health. Statistical determinations are not available, as far as I know, that would furnish us with a statement of what might be called a "normal state of health" for various periods of life. It is evident that there must be degrees of disease, that vary from one that is not determinable by any of our present methods of diagnosis to one that is plainly recognizable as such a departure from the normal that we can characterize it as disease. The great Claude Bernard pithily remarked: "The healthy are really invalids unaware of their illness."—(Garrison). Disease and health, then, are correlatives not clearly distinguishable from each other at certain stages. Everything that lives is constantly menaced by one external agent or another and is therefore subject to disease in varying degree, according to circumstances. The botanist, zoologist and other biologists here present will bear me out in this statement. Plant pathologists and immunologists have shown how great is the number of bacterial, virus, fungoid, algal and other infections of plants, and that in their reaction to disease plants behave in a manner not fundamentally distinct from that seen in animals. There is an essential unity in living things in all their innumerable and varied forms. The potentialities of life are illimitable in kind and degree in respect to its chemical, physical and architectural capacities.

Striking examples of the manner in which the protozoa and other lower forms of animal and plant life react to invasion by bacteria and other injurious agents are found in scientific writings before the middle of the last century. Metchnikoff, who was himself a student of the infectious diseases of the protozoa, as well as those of man, has expressed the opinion that the causes of infectious diseases might have been disclosed before the 70's and 80's of the last century, if students in that field of science had paid more attention to the comparative physiology and pathology of the 1830's.

We may now take up the main thesis of this address, namely, that innumerable chemical substances in our environment and, to a lesser extent, abnormal products in our own bodies are the direct inciting causes of a very large number of diseases. Without attempting to give an estimate of the number of such chemical agents, we may say that many of the derivatives of the constituents of the earth's crust, a great number of chemical principles of plant and animal origin, a large percentage of the hundred thousand and more synthetic products of the chemist's skill, such as the so-called "war gases" and those that are employed in our industries, are all capable of inducing serious diseases in man and his domestic animals and, within limitations, in the various forms of plant life on which he depends for his existence. The number of such active chemical agents, to which we must add all our drugs, is very large and runs far up into the thousands.

Man has never given up the search for substances that would either cure or alleviate his ailments, and this belief has been fully justified in the course of the ages. By trial and error and by planned experimentation in more recent times valuable remedies of preventive or curative character have been discovered. From early times also and in every corner of the globe man has sought for and found so-called "stimulants"—hypnotics, inebriants, mental sedatives and hallucinating substances—that affect his psychical states. Some of these, as opium, the coca leaf, the seeds and other parts of the Solanaceae, for example, have given us sedative and other principles of the highest value in medicine. Among western nations we find beer, wines and other alcoholics, coffee, tea and tobacco in daily use as "stimulants," and people in general do not speak of them as poisons, and very properly so, when they are used in moderation, with due regard to age, state of health and other factors.

For more than a century medical scientists and biologists have occupied themselves with the action of chemical substances, to use a most inclusive term, on man and other forms of animal life and also on various kinds of plant life. The effects produced in living cells vary from barely perceptible functional or physiological and micro-structural alterations to structural alterations of such character and degree that life can no longer persist. I have long held the opinion that every reversible functional change in a cell or cell state is accompanied by a reversible, if only microphysical, alteration of structure which, in many instances, as in the autonomic nervous system, for example, can not be detected by present-day methods.

The word *reversible* is not here used in the sense of the physicist when he speaks of a *reversible process*, but only to designate a departure from the normal state of an organ where *restitutio ad integrum* finally occurs. But even in physiological and structural restitutions a price has to be paid, but this can be done because of the peculiarly favorable mechanisms involved and because the energy needed for the restitution can be supplied as needed by other structures of the body. Extreme departures from the normal can not be too often induced at short intervals without final damage to the system in which they occur.

Scientists place great emphasis on the fact that living mechanisms are endowed with the capacity to *retard* the degradation of energy that occurs in other natural processes. This retardation, as is well known, is seen at its best in the plant world. We should not, however, regard the storage of potential energy by plants and the delayed increase in entropy during their span of life as something that sharply and uniquely differentiates them from nonliving systems. The physicist, C. E. Guye, of Geneva, has pointed out in his philosophical essays on physicochemical evolution that in the system, ocean-water-vapor-atmosphere-mountain-ocean, we have, at the expense of solar energy, an arrangement in which there also occurs a retardation in the increase of entropy. The water evaporated from the ocean rises in the air, descends to mountain tops, gives rise to water courses that do mechanical work in eroding their beds and in other ways, and in due time the cycle is completed with a marked retardation of the degradation of energy. "In this way evaporation struggles against an immediate degradation of energy just like plant organisms . . . it would be wrong to attribute to the vital processes an exclusive monopoly of the struggle, if it is desired to speak of the striving against the degradation of energy."

Two great lines of investigation are always to be borne in mind in these studies of the interaction, or interplay of actions, between the agent studied and living cells. What changes have taken place in the chemical structure of the agent during its sojourn in the living thing? A very large number of substances have been studied from this point of view, and such studies come under the heading "fate of the substance in the organism." The ability of living systems of all kinds to effect the most varied and profound chemical alterations in substances that are not found in their own cells—substances that are new and strange to them, so to speak—is most extraordinary. The discoveries in this branch of pharmacology to which many specialists have devoted years of research have greatly enlarged our knowledge of the chemical mechanisms here concerned. Many agents penetrate deeply into the citadel of life, and what life does to them in a chemical way is all in the day's work and differs, as a rule, in quantitative fashion only from the usual routine of metabolism. However, there are many instances when the living organism forms, in response to the appropriate agent, an apparently entirely new substance, which it has never before produced. Substances of this class have become of the greatest theoretical and therapeutical importance within the lifetime of the seniors among us, and are named antitoxins or immune bodies. I regret that I have not time to discuss this interesting subject further in this brief address.

The other great field of research in the interplay of actions referred to is far more difficult and more complicated than is the study of the fate of a chemical substance in the organism. It occupies itself with the functional and structural alterations induced by chemical agents taken in from the environment or formed in various cells of the organism itself. It would take me too far afield to say anything in respect to these numerous and varied functional alterations, but I shall, however, permit myself to say a few words in regard to the structural changes produced by certain doses of our chemical agents acting over a shorter or a longer period of time. Here I shall not take into consideration highly corrosive agents, such as strong acids, alkalis and other substances of inorganic nature, but will confine my remarks solely to those agents that belong to organic chemistry. Substances of this class, as I said earlier in this lecture, are the direct or proximate cause of many diseases.

A few examples only of diseases of chemical origin that may cause profound structural alterations in various tissues of the body can be cited here. Among these are the gangrenous and convulsive types of ergot poisoning, which, from the early middle ages to our own time, have destroyed thousands of lives or have permanently maimed an even larger number of people; the many forms of forage disease that so often destroy cattle, horses and sheep, and the infectious diseases of these and other domestic animals, in so far as the causative agent of these diseases is a definite chemical principle. Other examples of chemically induced disease are found among those produced in man by the numerous varieties of pathogenic microorganisms. Of the many diseases due to this large class of agents I can take into account here only such diseases of man as are caused by the bacillary forms. Many bacteriologists and pathologists now incline to the belief that, in the greater number of such infections, chemical agents play the dominant rôle in the observed symptoms and in the cellular lesions that finally occur. They believe that there are excellent reasons, based on both experimental and clinical observations, for believing that toxins are elaborated during the course of all bacterial infections, even though the exact origin and nature of these toxins is not always known. It has been demonstrated, however, that in some of the infectious dis-

eases of this class, such as tetanus, diphtheria and botulism, the bacillus in each instance serves only to produce a toxin which is responsible for the chain of events. I shall give presently a brief account of some of our experiments with the toxin of tetanus; but I wish particularly to impress upon your minds the fact that when the pathologist studies the lesions that occur in human beings and animals as the result of the above-named and many other forms of chemically induced disease, he is confronted with the same evidences of direct injury to cells, particularly those of highly specialized function, as are encountered in diseases whose etiology is less definitely established.

It was remarked in a preceding part of my address that everything that lives is constantly menaced by one external agent or another and is therefore subject to disease. It was also shown that there are autogenous sources of disease whose primarily inciting causes or etiology are not always known. Disease in its reversible early stages can not be more clearly defined until we are better informed in respect to the many chemical and physical processes and the composition and function of the many microphysical structures that are concerned with the maintenance of the ever-varying "normal state" of cells or cell states. When disease reaches that stage where, in one or more organs of the body, inclusive of the entire nervous system, functional or structural deviations from the condition called health are recognizable by the clinician and the pathologist, and especially when death ensues, we are all too ready to regard disease from our human point of view as something that a kinder nature might have ordered otherwise. In the wider biological conception disease is no more and no less malevolent or purposeful than any other of the fundamental processes or characteristics of life. Whether it has a "survival value" in the philosophy of evolution I can not say. Old age is our last disease.

I have attempted to give you in a very general but inadequate way some conception of the very large number of poisons of organic and inorganic origin that are capable of inducing disease. Only a very few of the many diseases whose cause is definitely assignable to agents of this character could be named in our brief summary. I am far from asserting that all the departures from the normal state that are due to poisons can always be differentiated from each other in all their stages as separate clinical entities. In the early stages of poisoning, as also in the later chronic period and especially when the patients are entirely unaware of the inciting cause of their illness, the physician is limited to the study of the complexes of symptoms, called syndromes, that may vary from the organic or physical to the psychopathic, or a combination of these types, and he may be quite unable to say from the evidence at hand what poison has caused the illness or, in fact, that it is due to any poison. When, however, the symptom-complexes include one or more elements either of a functional or structural type, or a combination of the two, that are uniquely characteristic of the action of a well-known poison a more complete diagnosis can be made. In the great majority of instances of chemically induced disease the fact is easily established that one or more poisons are involved. We have also seen that, in many of the clearly recognizable infectious diseases, the efficient agent that produces the morbid state is a poison generated by the infective microorganism. We have furthermore gone so far as to believe that there exists in organized nature not a single living cell whose contents or metabolites are not toxic for some other living thing, or may not on occasion be injurious to the cell itself. I can not but believe that the subject-matter of my address, with whose central thought many of you are entirely familiar, has become, in our day, of great significance for every department of medicine as well as for many aspects of biological research.

(To be concluded)

OBITUARY

ALFRED FABIAN HESS[1]

THE Harvey Society learns with profound regret of the death of the distinguished president of the society, Alfred Fabian Hess. In the lengthening list of its presidents, none has been more devoted to its interests, none has sought more earnestly to maintain its fame, none has devoted more energy to the realization of its purposes. He exhibited his sympathetic attitude by consenting to return to a former custom of the society to occupy his office for two successive terms. In the second of these, unexpectedly and in the full tide of his powers, his grievous loss is sustained. He has been a member since 1911 and has himself been one of its lecturers (January 15, 1921).

Dr. Hess has numerous claims to the high regard of his professional colleagues. Beyond the custom of most men, his life was given solely to the interests of his calling. He knew no divided allegiance; the whole of his thought and energy exhibited extraordinary singleness of purpose. A life of contented leisure, so easily within his choice, he exchanged by

[1] Minutes adopted by the Harvey Society at a meeting held on December 14. The committee appointed to draw up the minutes consisted of James W. Jobling, William H. Park and Alfred E. Cohn.

preference for one of laborious days. These he consecrated to the furtherance of useful knowledge, and this he placed unreservedly at the disposal of his fellow men. Two books and 225 separate contributions to journals are witness to this choice and serve as his fitting memorial.

His researches fall into two categories. There is an earlier one in which his activities were dominated by the prevailing interest in communicable diseases. His thought took, as it usually did, two directions, one social, one scientific. Problems connected with the spread of tuberculosis engaged his attention first. In the Laboratories of the Department of Health in this city he studied "The Incidence of Tubercle Bacilli in New York City Milk" (1909), an investigation which led to important recommendations for the protection, especially of infants, from infected milk. The concern which he entertained for the welfare of children led him to suggest a plan for the institutional treatment of infants exposed to this scourge. To this end he developed the idea of "A Tuberculosis Preventorium for Infants" (1917) which led then to the realization of a Preventorium for Infants at Farmingdale, N. J. At this period he was interested also in certain phases of other communicable diseases. In writing on "A Protective Therapy for Mumps" (1915) he discerned in the method he was proposing a solution not merely of special importance but one—and this was eminently characteristic of the penetrating quality of his reflective nature—involving a general principle, applicable to the treatment of measles and since then tested in relation to other comparable diseases.

Although he retained his interest in communicable diseases, he soon turned, at the Laboratories of the Board of Health and later in the Home for Hebrew Children and the laboratories of the College of Physicians and Surgeons at Columbia University, to his studies on scurvy and on rickets. Investigations on these subjects he continued to pursue with unflagging energy throughout his life. It was this field to which his main and outstanding contributions to knowledge were made. At the time of his death he was engaged in analyzing no less than six separate aspects of these problems. How extraordinarily fruitful these researches were, it is perhaps too early completely to appreciate. In number alone, their wealth bears witness to his very great industry. But meritorious in itself, industry alone would not have achieved for him his well-earned fame. In more than one direction he broke new paths. The subject is so well known as to require no extended description—the relation of scurvy and rickets to the vitamins, the influence of sunlight and the seasons on the progress of the disease rickets, the importance in its treatment of artificial light, of various foods and of various oils, the development of non-potent into potent agents when exposed to ultra-violet rays. In these researches his prime endeavor was to extend knowledge, but his critical intelligence was content with nothing less than that pitfalls due to too early generalization should be avoided; anti-rachitic agents he saw were not of equal value, for they exhibit differences depending on their origin and on their utilization. And in this case, as in that of tuberculosis, he did not lose sight of the wider prophylactic uses to which his investigations could be put; he saw to it that the general public benefited by making practical underlying theoretical considerations.

The method by which he carried on his activities is not the least of the interesting phenomena which distinguish the ways of this gifted man. Having entertained an idea—and he had many—he tested it, first rationally, with the utmost meticulousness. He defined it carefully in words, so that by observation and experiment he was in position to know precisely what it was which he wished to subject to exact analysis. Having analyzed it, he was not content unless an experiment, which to him was never more than an analogue, was genuinely illustrative of a clinical situation. If he found a solution to an initial question, he proceeded to further development or elaboration of the plan originally entertained. It was an impressive intellectual process, slow and careful procedure from step to step, which those who knew him came to appreciate and which those who knew him less intimately did not in the end escape from recognizing.

How devoted he was to the acquisition of knowledge, quite apart from its meaning for his personal career, can be discerned from a further study of his technique. His investigations forced upon him the need to rely upon methods, both chemical and physical, with which his own education and later training, had not prepared him. From the challenge of their use he did not shrink. In principle, and for his purposes, he developed a sure acquaintance with their significance. But, from a personal technical utilization of them he had the good judgment to refrain. His disinterestedness in the pursuit of knowledge and his generosity in sharing his ideas are exhibited with singular clearness when he found himself in this situation. It was then that he turned to other men, suitably equipped, to come to his aid. His insight into problems connected with the physics and chemistry of the vitamins was in fact unusually penetrating. His prophetic vision on more than one occasion forced upon reluctant associates enthusiasm sufficient to embark on researches which, without his stimulation, would not then have been undertaken. It is a general judgment that the organic chemistry of this

group of substances is richer as a result of the interest which he aroused and to which he turned as the result of his clinical experience. He knew his limitations, but he knew also how to surmount them. He not only cultivated a field, but he shared its cultivation with his fellows.

This description of a singular man would be incomplete if other aspects of his personality were left unmentioned. Aside from his industry, aside from his scientific insight, aside from his inventiveness, he had an unusual historical sense. Were this side of his interests not known otherwise, it would emerge from reading those chapters in his book on rickets in which he describes the history of this disease. He cared not only for knowledge of the development of ideas (in regard to it), but he charged himself with the collection of the literature of this subject and has by his collection made the library of the New York Academy of Medicine the richer. Those who were privileged to sit with him on the committee of that library were aware of his sensitiveness to the meaning of the march of ideas in the development of conceptions.

He was conscious also of another obligation. As a scientific man, he made the interests of scientific men his personal concern. In this city, in which social intercourse among like-minded men is difficult, he made of his home a center of hospitality, a center for the discussion and exchange of ideas. That the discussions were uniformly elevated and of a high seriousness, the character of the man amply assured.

Wherever on the numerous sides of interest appropriate to the lives of medical men one looks, the death of Alfred Hess marks loss. He touched life in many of its phases; wherever he touched it, he enriched it. Without the opportunity for disciples, his intellectual vigor, his disinterestedness, his pungent personality impressed itself upon his contemporaries.

The Harvey Society is conscious of its loss. To his associates, to his friends, to his family, it expresses its deep sympathy.

RECENT DEATHS

ROBERT HENRY SMITH, professor emeritus of the Massachusetts Institute of Technology and for forty-seven years a member of the staff of the department of mechanical engineering, died on December 11 at the age of seventy-one years.

JOHN SABIN ADRIANCE, formerly professor of physiological chemistry at Williams College, died on January 5. He was seventy-three years old.

DR. FREDERIC WILLIAM SEARS, neurologist and professor of nervous diseases in the College of Medicine at the University of Vermont, died on January 2. He was seventy-four years old.

THE death is announced of Dr. Wilhelm Scholz, professor of internal medicine, and of Dr. Oskar Zolte, professor of physiology, both of Graz.

THE *British Medical Journal* announces the deaths of Professor Max Zondek, the Berlin urologist, aged sixty-five years; Professor Joseph Imre, the Budapest ophthalmologist; Dr. Artur Algar, a prominent dermatologist of Vienna, aged sixty-seven years; Dr. Auguste Rickli, head of the Swiss Red Cross, aged seventy years; Dr. Johann J. Jörger, honorary member of the Swiss Society for Psychiatry, aged seventy-two years; Dr. Wilhelm Prausnitz, emeritus professor of hygiene at Graz, aged seventy-two years; Professor Edmund Forster, director of the university nerve clinic at Greifswald, aged fifty-five years, and Dr. G. Lemière, honorary professor at the Lille faculty of medicine.

SCIENTIFIC EVENTS

EXHIBIT OF THE PHYSICAL SOCIETY, LONDON

THE twenty-fourth exhibition of scientific instruments and apparatus arranged by the Physical Society of Great Britain was held from January 9 to 11 at the Imperial College of Science and Technology, South Kensington.

In the trade section 81 firms showed their latest products. The research and experimental section displayed instruments which have not yet reached the stage of commercial production, and apparatus built for special tests or for research in pure physics. Teachers from universities and scientific institutions demonstrated methods which they have recently devised to illustrate some principle or application of physics.

There was an exhibit of recent applications of light-sensitive cells to the control of industrial processes. Such a cell is employed in a device for applying an even tension to a yarn in reeling. The apparatus comprises a tension leveller and a tension applier. In the tension leveller, small variations in tension in the yarn from the bobbins are made to alter the emission current of a photo-cell. This current is amplified through a gas-filled relay circuit to operate a subsidiary electromagnetic brake.

Another device which is finding fresh fields of usefulness is the cathode ray tube. This contrivance generates a stream of electrons which is rendered visible where it impinges on a fluorescent screen; by electrical or magnetic means the stream can be deflected. It is employed in television, and in the cathode ray oscillo-

graph, which can be used to demonstrate alternating-current phenomena; and there are other applications in industrial engineering, where a continuously operating visual indicator is required.

A new apparatus this year was a multiple etching machine which marks 15 stainless knives or other articles at a time by an electrical process. The work is stated to be done four times as rapidly as by the old acid etching process, and at a fifth of the cost. A camera has been designed for tricolor photography where exposures at snapshot speed are necessary, and there is a new two-color cinema camera also in which ordinary sub-standard film is used. Recent devices bearing on physiology include an instrument designed to measure, for an actual lighting installation, the depression of eye sensitivity caused by exposed bright sources of light in the field of view; and apparatus also for studying the effect of concentrated high-frequency fields on bacteria cultures and pathological specimens.

AN EXHIBIT OF INDUSTRIAL CHEMISTRY AT THE NEWARK MUSEUM

As a new chapter in its series of industrial exhibits, the Newark, N. J., Museum has in preparation an exhibit for the layman which will be known as "Chemistry Changes Our World: an Exhibit of the New Discoveries for Industry and the Home." It will open about the middle of March. This is in furtherance of the museum's policy of presenting exhibits related to the industries of its community, but because of the scope and timeliness of the exhibit of industrial chemistry, it is expected to attract national interest.

Already over a hundred national firms have accepted invitation to cooperate. Among the first to offer cooperation were E. I. du Pont de Nemours and Company, Incorporated, Celanese Corporation, the Bakelite Corporation, the Beetleware Corporation, E. R. Squibb and Sons, the Celluloid Corporation, Westinghouse Electric Company, Public Service Electric and Gas Company, Texas Gulf Sulphur Company and others. Among those who have offered to act in an advisory capacity to the exhibit, are Dr. E. C. Worden, of the Worden Laboratories; Professor William T. Read, of Rutgers University; Dr. John H. Schmidt, chairman of the North Jersey Section of the American Chemical Society, and Donald Deskey, decorator, of New York City.

Special educational features of interest to the general public are being scheduled for the duration of the exhibit. A series of speakers prominent in the field of industrial and research chemistry are being invited to talk in explanation of various aspects of the exhibit. A series of educational moving pictures dealing with chemistry is also being arranged. A living room, designed by Donald Deskey, the New York decorator, and furnished entirely with synthetic materials, is expected to be one of the most popular features.

Previous industrial exhibits held by the Newark Museum include an aviation exhibit, held in 1932, which had an attendance of 85,000; a leather exhibit, held in 1920, which had an attendance of 75,000, and exhibits of pottery, floor coverings and textiles. The "Chemistry Changes our World" exhibit will remain at the Newark Museum, opposite Washington Park, Newark, N. J., for two months at least.

THE NEW YORK STATE EXPERIMENT STATION AT GENEVA

PROGRESS on more than one hundred and fifty farm research projects under way at the State Experiment Station at Geneva is briefly noted in the fifty-second annual report prepared by Dr. U. P. Hedrick, director. A copy of the report may be obtained upon request to the station.

In commenting on the report, Dr. C. E. Ladd, dean of the College of Agriculture, states that this has been an unusually productive year at the station. The farmers of the state have brought their problems freely to the research workers and the new facts developed by the station have been eagerly accepted and put into practise. The agricultural depression, an increasing tendency to specialization in crop production, and the increasing number of plant and animal diseases and insect pests lay an ever-changing and an ever-increasing group of problems at the door of the agricultural research worker. His very success in solving these problems brings new crops of problems.

The research work at the station falls under the general headings of agricultural bacteriology, botany and plant diseases, chemistry, dairying, entomology, pomology and vegetable crops. The work in each of these divisions is dealt with in the report.

Dr. Hedrick points out particularly the advantage to the work of the station of the new greenhouse equipment provided during the past year and also stresses the educational value of the improvements that have been made around the grounds in the way of ornamental plantings and landscaping. With regard to the latter project, he says, "The effort to improve the grounds are primarily to make them more presentable, but it turns out that the work has considerable intrinsic value besides. Many persons come to the station to study the species and varieties that thrive best in this locality, while the station specialists have an opportunity to study the insect pests and diseases of ornamental plants and thus are able to answer questions on the control of these pests at which in times past they had to guess."

BRITISH HONORS

FROM the New Year Honors List *Nature* selects the following names of scientific workers and others associated with scientific work: *K.C.V.O.:* Sir Richard Glazebrook, chairman of the Aeronautical Research Committee, 1908–33. *Knights:* Dr. S. C. Cockerell, director of the Fitzwilliam Museum, Cambridge; G. Evans, principal of the Imperial College of Tropical Agriculture, Trinidad; Dr. Kenneth Lee, chairman of the Industrial Grants Committee, Department of Scientific and Industrial Research; Colonel C. E. Merrett, president and trustee of the Royal Agricultural Society, State of Victoria; Professor Robert Muir, professor of pathology, University of Glasgow; Dr. C. T. Hagberg Wright, secretary and librarian of the London Library. *C.S.I.:* Brigadier R. H. Thomas, lately Surveyor-General of India. *C.M.G.:* Professor R. E. Alexander, director of Canterbury Agricultural College, Lincoln, near Christchurch, New Zealand; Mr. A. Holm, lately director of agriculture, Kenya. *C.I.E.:* Lieutenant-Colonel A. D. Stewart, director of the All-India Institute of Hygiene and Public Health, Calcutta; Lieutenant-Colonel Ram Nath Chopra, professor of pharmacology, School of Tropical Medicine and Hygiene, Calcutta. *C.B.E.:* J. S. Buchanan, deputy director of technical development, Air Ministry; R. G. Hatton, director of the Horticultural Research Station, East Malling, Kent. *O.B.E.:* G. H. J. Adlam, senior science master, City of London School; M. C. C. Bonington, lately divisional forest officer and forest development officer, Andamans; C. Coles, principal of Cardiff Technical College; D. Mackay, for service in connection with scientific exploration and survey in the interior of Australia; Professor W. Makower, professor of science, Royal Military Academy; Dr. P. D. Strachan, superintendent, Leper Settlement, Botsabelo, Basutoland; H. B. Thomas, deputy director of surveys, Uganda Protectorate; A. H. Unwin, conservator of forests, Cyprus. *M.B.E.:* A. S. Buckhurst, assistant in the Plant Pathological Laboratory, Harpenden; B. J. Hartley, district agricultural officer, Tanganyika Territory; C. A. Pinto, curator in the Zoological Gardens, Lahore, Punjab; M. J. S. Rosair, extra assistant conservator of forests, Burma.

IN HONOR OF PROFESSORS OF MATHEMATICS AT THE UNIVERSITY OF WISCONSIN

A BANQUET in honor of three members of the faculty of mathematics at the University of Wisconsin was recently given by friends, associates and students. These were Professor Charles S. Slichter, dean of the Graduate School; Dr. E. B. Skinner, professor of mathematics, and Dr. E. B. Van Vleck, emeritus professor of mathematics. A number of representatives from the departments of mathematics of other universities were present. They included Professor George D. Birkhoff, of Harvard University, who formerly taught at Wisconsin; Professors G. A. Bliss and E. P. Lane, of the University of Chicago, and Professor T. F. Holgate, of Northwestern University. In addition, Professor Warren Weaver, who left Wisconsin two years ago to join the Rockefeller Foundation in New York, returned for the occasion.

Speakers at the banquet included President Glenn Frank; Dr. E. A. Birge, president emeritus of the university; George C. Sellery, dean of the College of Letters and Science; Professor Birkhoff and Dr. Weaver. The guests of honor also spoke. Professor Mark Ingraham, of the department of mathematics, acted as toastmaster.

Dean Slichter holds the longest record of service—forty-seven years. He became an instructor of mathematics in 1886, was made assistant professor in 1889 and professor in 1892. Since 1920 he has served as dean of the Graduate School. Professor Skinner joined the faculty as an instructor in mathematics in 1892, forty-one years ago. He became assistant professor in 1910 and since 1920 has been professor of mathematics. Professor Van Vleck became instructor of mathematics in 1893. In 1895 he left the university, but returned as full professor in 1906. He became an emeritus professor in 1928. The three men have a combined service record in the university of one hundred and sixteen years.

SCIENTIFIC NOTES AND NEWS

PROFESSOR GILBERT A. BLISS has been awarded the Martin A. Ryerson Distinguished Service Professorship for his "brilliant and fruitful service to the University of Chicago." Of the nine distinguished service professorships two are now held by members of the department of mathematics, the Eliakim Hastings Moore Distinguished Service Professorship having been awarded to Professor Leonard Eugene Dickson several years ago.

PROFESSOR HERBERT E. SLAUGHT, emeritus professor of mathematics of the University of Chicago, was at the Boston meeting elected honorary president for life of the Mathematical Association of America.

THE gold medal of the Royal Astronomical Society, London, has been awarded to Dr. Harlow Shapley, director of the Harvard College Observatory, for his work on the structure and dimensions of the galactic system. On May 11 Dr. Shapley will deliver the annual George Darwin Lecture to the society.

WILLIAM LAWRENCE BRAGG, Langworthy professor

of physics in the Victoria University of Manchester, and co-recipient of the Nobel Prize for physics in 1915, for work on x-rays and crystal structure, will be the George F. Baker non-resident lecturer in chemistry at Cornell University during the spring term of 1934. Professor Bragg's lectures will consider the methods of analysis by x-rays, the optics of x-rays, and will also discuss the structures of various simple and complex salts as shown by this method. He is expected to reach Ithaca about February 7, and his first public lecture there will be delivered on February 19.

SIR ARTHUR STANLEY EDDINGTON has been appointed Messenger Lecturer at Cornell University this year. He will give a series of twelve lectures on "New Pathways in Science," beginning on Monday, April 9. He will give three lectures a week, on Monday, Wednesday and Friday afternoons, and will conclude the series on May 4. The titles of the lectures are as follows: "Science and Experience," "The End of the World," "The Decline of Determinism," "Indeterminism and Quantum Theory," "Probability," "The Constitution of the Stars," "Cosmic Clouds and Nebulae," "The Expanding Universe," "The Constants of Nature," "The Theory of Groups," "Criticisms and Controversies," and "Epilogue."

GEORGE W. HESS, for more than twenty years director of the United States Botanic Garden, Washington, D. C., would automatically retire by reason of age on June 14, but Congress probably will not allow the garden to lose his services entirely. A bill has been introduced in the House of Representatives by Representative Keller, of Illinois, chairman of the House branch of the joint committee on the Library of Congress, which is the body controlling the garden, to create the post of "director emeritus and consultant of the U. S. Botanic Garden." The new post would pay $5,000 a year.

THE Pittsburgh Section of the American Chemical Society has selected Dr. Ralph E. Hall, director of the Hall Laboratories, Inc., Pittsburgh, Pa., as the recipient of the 1933 (the first) Pittsburgh Award. This honor, which will be conferred on Dr. Hall at the sectional meeting on February 15, has come to him in recognition of his distinguished service to chemistry and humanity, particularly his contributions to the fundamental knowledge of boiler-water reactions and their applications to the practical solution of boiler-water problems, his discoveries and technical accomplishments in the beneficiation and conditioning of water for industrial and domestic use, and his developments in the production of chemicals for these purposes. The Pittsburgh Award is represented by an especially designed plaque of gold, on which the relation of chemistry to industry is symbolized.

A DINNER in honor of Dr. G. S. Hopkins, on his retirement as active professor in the New York State Veterinary College, was given at Willard Straight Hall, Cornell University, on January 12. Dr. Hopkins is an original member of the faculty of the college. The dinner was sponsored by the alumni and was attended by over two hundred friends and colleagues. Dr. W. A. Hagan was toastmaster. The speakers were as follows: President Farrand, who represented the university; Professor S. H. Gage, the original faculty; Dr. D. H. Udall, the present faculty; Dr. L. E. Moore, the alumni, and Dr. Hopkins.

GOVERNOR MOORE of New Jersey announces that Professor Albert Einstein has accepted an invitation to a state-wide reception in his honor in March at the Atlantic City Convention Hall. The event is being sponsored by New Jersey Jews, seven hundred of whom it is reported dined with the governor at the Jewish Community Center in Jersey City on January 21 to further plans. Governor Moore served as honorary chairman and named a reception committee of educators, industrialists and public officials.

THE Council of the British Scientific Instrument Research Association held an informal luncheon in London on December 21 in honor of Sir Herbert Jackson, director of research of the association from its beginning in 1918 until July 31, 1933. Some thirty members of the council and friends, representing the scientific instrument industry, attended. After the luncheon presentations were made to Sir Herbert and Lady Jackson.

DR. ROBERT P. FISCHELIS, secretary and chief chemist of the Board of Pharmacy of the State of New Jersey, and lecturer in industrial pharmacy at the Philadelphia College of Pharmacy and Science, has been elected president of the American Pharmaceutical Association for the year 1934–35. He will take office at the annual convention of the association to be held in Washington either in May or August, at which time the new headquarters building of the association will be dedicated. This building is adjacent to the building of the National Academy of Sciences on Constitution Avenue.

H. W. BRINKMANN, assistant professor of mathematics at Harvard University, has been appointed to an associate professorship at Swarthmore College.

PROFESSOR G. F. MARRIAN has been appointed associate professor in the department of biochemistry of the University of Toronto.

PROFESSOR JOSEPH L. KLAMON, of the Washington University School of Business and Public Administration, has been granted leave of absence until March to accept an appointment as principal agricultural economist in the Agricultural Adjustment Administration.

Professor Klamon is now in Washington, where he expects to work in the Dairy Division and in the Commodities Division of the Department of Agriculture.

ELMER B. BROWN, for the past ten years research chemist at the Fleischmann Laboratories, New York, N. Y., has joined the research staff of the Upjohn Company, Kalamazoo, Mich.

DR. HARRY M. LITTLE, of Texas, has recently gone to Pittsburgh, Pennsylvania, to be psychologist at the Pittsburgh Child Guidance Center, which was recently established under a grant of the Buhl Foundation.

APPOINTMENT of Redfield Proctor, formerly governor of Vermont, to the executive committee of the Massachusetts Institute of Technology, is announced. Mr. Proctor will serve during the absence of Professor Elihu Thomson, now recovering from an illness. Mr. Proctor is president of the Technology Alumni Association.

DR. ADOLPH LORENZ, Viennese surgeon, arrived on January 20 for his annual visit to America to treat the many patients that he has in this country. Dr. Lorenz will be eighty years old on April 21.

DR. KARL LANDSTEINER, member of the Rockefeller Institute for Medical Research, has been appointed Cutter Lecturer in preventive medicine at Harvard University for 1934.

JEROME ALEXANDER addressed the Columbus, Cleveland and Akron, Ohio, sections of the American Chemical Society, on January 15, 16 and 17, his subject being "Some Intracellular Aspects of Life and Disease."

DR. E. STARR JUDD, professor of surgery at the Mayo Foundation, has endowed an annual lectureship in surgery at the University of Minnesota. The first Judd Lecture will be given by Dr. Dean Lewis, president of the American Medical Association and professor of surgery at the Johns Hopkins Medical School, on February 13. The subject of the lecture will be "The Hypophysis, the Master Gland: the Histology, the Physiology and the Clinical Syndromes Associated with its Lesions." Dr. Judd is a graduate of the Medical School of the University of Minnesota of 1902.

THE annual Alpha Omega Alpha Lecture of the Jefferson Medical College was delivered by Dr. Vilhjalmur Stefansson. The lecture described his Arctic explorations and his experiences while living on a purely meat diet north of the Arctic circle and in the United States under ordinary business conditions.

PROFESSOR C. H. BEST, of the University of Toronto, gave a course of three lectures at University College, London, on January 11, 15 and 18, on "The Rôle of the Liver in the Metabolism of Carbohydrate and Fat."

Nature states that a conference on atomic physics will be held under the auspices of the Physical Society. It will be opened by Lord Rutherford, and will probably extend over two days at least, some of the meetings being held in London and some in Cambridge.

THE French Association for the Advancement of Science will hold in 1934 its meeting at Rabat (Morocco) during the Easter vacation between March 24 and April 10 under the patronage of M. Ponsot, president general, and under the active presidency of Professor Lemoine, director of the National Museum of Natural History at Paris.

THE Fourth International Conference of Applied Mechanics will be held at Cambridge, England, from July 3 to 9.

THE fiftieth session of the American Association of Anatomists will be held in Philadelphia, at the University of Pennsylvania School of Medicine, on March 29, 30 and 31. Information may be obtained from the secretary, Dr. George W. Corner, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.

THE Midwestern Psychological Association will hold its ninth annual meeting as guests of Purdue University, Lafayette, Indiana, from May 10 to 12, under the presidency of Dr. J. J. B. Morgan. Correspondence concerning the meeting may be addressed to the secretary, Dr. John A. McGeoch, Department of Psychology, University of Missouri, Columbia.

DR. WILLIAM LAMBERT RICHARDSON, formerly professor of obstetrics and dean of the Harvard Medical School, who died in October, 1932, bequeathed $100,000 to the president and fellows of Harvard College to endow a professorship of obstetrics. He also gave $40,000 to establish the Jeffrey Richardson fellowship in the Harvard Medical School, the income to be awarded each year by the Faculty of Medicine to some deserving student of the Medical School who wishes to continue his studies after graduation.

MORRILL HALL of the University of Tennessee was razed early on January 18 by a $300,000 fire which destroyed irreplaceable scientific instruments, botanical and other specimens and research data. Authorities said that the building itself was valued at $75,000 and that the $225,000 estimated loss on its contents did not take account of intrinsic values. A collection of 30,000 botanical specimens, in process of assemblage since 1875, was insured for $1 each, but is said to be estimated at $10,000,000.

MORE than two million dollars had already been taken in one year from funds for scientific research in the U. S. Department of Agriculture before the pres-

ent fiscal year began with its reduced appropriations. The estimated expenditures for experiment and scientific research in the field of agriculture were $13,898,047 for the year which ended on June 30, 1933. This was a reduction of $2,434,930, or nearly 15 per cent. below the amount devoted to this work in the year previous. These figures were prepared by the U. S. Department of Agriculture at the request of the United States Senate, and are now given in the report just made public as a Senate Document. More than 70 per cent. of this "saving" was in compensation to the personnel working on scientific investigation. Altogether $1,741,552 was taken from the salary checks of workers on scientific projects—$1,188,856 being in the form of the general federal pay cut, and the remainder, about half a million dollars, representing amounts saved through administrative furloughs and dismissals. Altogether 567 workers on scientific projects were dismissed from the Department of Agriculture.

DISCUSSION

SOME ERRONEOUS AGE RECORDS OF PALEOZOIC PLANT GENERA

FIFTY years ago the statement that Welsh anthracite coal is characterized by its very low ash (3 per cent.) was still to be found in authoritative textbooks. This glaring misrepresentation, now only too obvious to most householders using anthracite from any source, has only in very recent years passed wholly out of common belief, but the erroneous theory, associated with and apparently founded, in part at least, on it, that anthracite was formed from vegetation different from that composing other coals, is still deep-rooted in many quarters. The ghost of a false record often haunts the literature for a generation or more after it has been exorcised by the specialists in the particular field to which it pertains. The purpose of this paper is to "lay" several ghosts of error relating to the geological range of certain genera of Paleozoic plants.

The genus *Taeniopteris* is nearly everywhere if not wholly confined to strata as young as Permian, of which it is characteristic, though it has a wide Mesozoic range. The plant described by me[1] as *T. missouriensis* is bipinnate and a *Desmopteris*. *Taeniopteris* is simply pinnate and petiolate. Zeiller's *T. jejunata*[2] goes out of the genus for the same reason. Lesquereux's *T. truncata*,[3] from the Allegheny, is a pinnule of *Neuropteris hirsuta* in every detail; the apex is folded backward incidental to burial. His *T. smithii*,[4] of unknown locality and stage, is probably a fragment of *Cannophyllites*, the geological level (upper Pottsville) of which was the source of most of the plants in Dr. E. A. Smith's collection.

Walchia antecedens Stur[5] from the Ostrau culm is a Lycopod, probably a *Lepidodendron*, lacking all diagnostic features of *Walchia*, which seems to have made its appearance in the latest Stephanian, notwithstanding Kidston's identification[6] of what is undoubtedly a leafy twig of *Lepidodendron*, from the Staffordian (Upper Westphalian) of Great Britain, as *W. imbricata*.

Most paleontologists know, though not all lay writers are informed, that the plant-bearing beds ("Fern Ledges," "Little River group," "Cordaites sandstones," etc.) in the vicinity of St. John and Lepreau, New Brunswick, from which C. F. Hartt, Sir William Dawson and G. F. Matthew described species of *Annularia, Asterophyllites, Palaeostachya, Sphenophyllum, Calamites, Callipteris, Neuropteris, Odontopteris, Cardiopteris, Aneimites, Megalopteris, Alethopteris, Pecopteris, Cordaites, Antholithus, Whittleseya* and *Trigonocarpum*, together with Matthew's genera *Ginkgophyton, Johannophyton, Lepidocalamus, Pseudobaiera* and *Ramicalamus* as Devonian, even Middle Devonian when not Silurian, are now unshakably proved Pottsville (Westphalian) in age. Similarly, the flora, once supposed Mississippian, from Rushville, Ohio, embracing *Alethopteris, Megalopteris* (name antedated by *Cannophyllites* Ad. Brongn.), and *Orthogoniopteris*, as described by Andrews, is of upper Pottsville age. Of these genera from New Brunswick and Rushville all except *Cardiopteris, Aneimites, Neuropteris, Calamites, Cordaites, Antholithus, Trigonocarpum* and *Sphenophyllum* are unknown below the Pennsylvanian. *Aneimites* is present in basal Mississippian. *Cardiopteris eriana* Dawson probably represents interpinnate rachial pinnules of a plant belonging to the *Neuropteris gigantea* stock. *Cardiopteris* proper is a Mississippian genus characteristic of the Chester. *Callipteris pilosa* Dawson is a *Sphenopteris*, as was noted by Stopes; *Callipteris* proper is the most wide-spread and characteristic genus of the Permian.

On the other hand, the plant from Rushville described by Andrews as *Archæopteris stricta*, which so far as found is a strictly upper Pottsville species,

[1] D. White, *Bull. Geol. Soc. Amer.*, 4: 119, pl. 1, 1893.
[2] C. Grand 'Eury, "Fl. carb. Loire," p. 121, 1877; R. Zeiller, "Fl. foss. bassin Commentry," Pt. 2, p. 280, pl. 22, figs. 7–9, 1888.
[3] L. Lesquereux, "Coal Flora," Vol. 3, p. 743, pl. 94, fig. 8, 1884.
[4] L. Lesquereux, *op. cit.*, Vol. 1, p. 153, pl. 15, fig. 7, 1880.
[5] D. Stur, "Culm Flora," p. 80, pl. 17, fig. 7, 1875.
[6] R. Kidston, *Trans. Roy. Soc. Edinb.*, Vol. 35, p. 324, pl. 35, fig. 9, 1888; *Proc. Geol. Polytechn. Soc. Yorksh.*, Vol. 14, p. 368, pl. 63, fig. 1, 1902.

has not yet revealed the frond structure characteristic of *Archæopteris,* which is typically upper Devonian the world over. Dawson's *Psilophyton* (?) *glabrum,* from the "Fern Ledges" at St. John, has after examination been referred by Stopes to *Dicranophyllum. Psilophyton* seems to have a rather extended vertical range in the Devonian.

The trunks from the Hamilton, at Gilboa, New York, described by Dawson as *Caulopteris* and *Psaronius,* lack the distinctive features of those genera, which, furthermore, seem to have borne Pecopterid fronds and to be confined to formations of Pennsylvanian and Permian age. The Gilboa trunks are, on the contrary, associated with, and, if I am not mistaken, belong to the trees described by Goldring as *Eospermatopteris.*

Sphenophyllum, the name of another genus unknown in rocks earlier than Carboniferous, was without warrant applied by Lesquereux[7] to a minute fragment, apparently algal, from the Silurian at Covington, Ky. The pre-Carboniferous record should be deleted.

The genus *Idiophyllum* (monospecific; *I. rotundifolium*) was founded by Lesquereux[8] on a single specimen of *Neuropteris,* probably *N. rarinervis* Bunbury, in circinate vernation. On the basis of the misleading figure in the "Coal Flora," in which the ultimate divisions of the rachis are drawn as lateral nerves, the name *Idiophyllum* was penciled by Schenk, in some at least of the copies of his Chinese flora distributed by him, in place of the printed *Megalopteris* Schenk (preoccupied by *Megalopteris* Hartt). Later he substituted a second name, *Gigantopteris,* by which the plant from the lower Permian is still known.

The generic correlation of the wide-spread Gondwanaland plant *Danæopsis hughesi,* present also in the Permian of the Far East, with Lesquereux's *Protoblechnum,* which it resembles, is evidently untenable, the Asiatic frond being dichotomous in structure, while *Protoblechnum* has a straight, undivided and broad petiolate frond. The American genus is probably confined wholly to the Pottsville, though it is apparently closely related to Sellards' *Glenopteris*[9] from the Permian of Kansas.

Callipteridium sullivantii Lesquereux, from the Appalachian Allegheny, is Alethopteroid in general features, including its architectural plan. In America the genus *Callipteridium* as now defined is very rare and has not been found in beds older than Conemaugh. In fact, most of the Dunkard plants referred to it are unquestionably Pecopterids; some may be *Cladophlebis.*

DAVID WHITE
U. S. GEOLOGICAL SURVEY

[7] L. Lesquereux, *Proc. Am. Phil. Soc.,* Vol. 17, p. 167, pl. 1, figs. 3–5, 1877.

[8] L. Lesquereux, *op. cit.,* Vol. 1, p. 160, pl. 13, fig. 11, 1880.

[9] E. H. Sellards, *Kans. Univ. Quart.,* Vol. 9, ser. A, p. 180, 1900.

A STARCHLESS POTATO INDUCED BY THE INTRODUCTION OF FOREIGN ENZYMES

FOLLOWING on a series of recent researches carried out in the laboratory of one of us (H. H.) relating to the synthesis and structure of polysaccharides from common sugars by bacterial action, such as levan obtained by the action of *B. subtilis* and *B. mesentericus,* dextran by the aid of *Leuconostoc dextranicus* and *mesenterioides* and cellulose by the use of *Acetobacter xylinus,* the possibility suggested itself of bringing about a change in physiological characteristics through the introduction into the growing plant of foreign bacteria or their corresponding enzymes with a resulting change in the nature of the polysaccharide formation. Previous investigations have established the structure of levan as a polymerized 2, 6-fructofuranose anhydride, so that a very close relationship exists between this polysaccharide and that formed in the Jerusalem artichoke, namely, inulin, which is known to be a polymerized 1, 2-fructofuranose anhydride.

In view of the similarity in structure of the artichoke and the common potato plant, the idea was conceived of introducing into the latter during growth, through the main stem, the levan enzyme, or its corresponding bacterial culture, with a view to bringing about the replacement of the starch in the potato tuber by another polysaccharide.

Young potato plants about 5 to 6 weeks old (10 to 12 inches high) were taken for this purpose. The tip of the main stem was removed and the bacterial culture (*B. subtilis*) was introduced by means of an attached tube. The treatment was repeated at intervals of several days for two and one half months.

From four plants out of about 30 investigated there was obtained a new type of potato, namely, one practically free from starch as indicated by the entire absence of any color on placing a section in iodine solution, except for a peripheral ring of tissue about one eighth of an inch wide.

These results would seem to establish the possibility of bringing about a change in the physiological characteristics by the external introduction of a foreign enzyme or bacterial culture into the growing plant.

The experiments are being continued with a view to ascertaining the reproducibility of such, and the effect of introducing a variety of other bacterial cultures into the potato and other plants is being investigated.

Further details of this work are to be published in the *Canadian Journal of Research* in the near future.

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A PROMISING CONTROL FOR PSYLLID YELLOWS OF POTATOES

THE feeding of the psyllid, *Paratrioza cockerelli* Sulc., causes a very serious disease condition in potatoes and tomatoes, known as psyllid yellows. It is the most serious problem for the potato growers of many western sections, and tomatoes are often very seriously injured. It has been estimated that the condition reduced the 1932 potato crop in Colorado as much as 8 million bushels.

Practically all sections of the state were infested, with some suffering a total crop loss. Production has become so uncertain in some important sections that the acreage has been very materially reduced. Reports indicated that the loss has been equally heavy in other western states.

The condition is characterized by an upward rolling of the basal portion of the terminal leaves, which may be somewhat smaller than normal and stand more or less upright. They early take on a chlorotic appearance that may develop to a distinct yellow and in extreme cases an early dropping of the leaves. The nodes become enlarged and all buds are abnormally active. The effect upon the tubers is just as pronounced. If the set has taken place the growth is checked. When the tubers are not definitely formed, numerous stolons are thrown out with small tubers forming into a chain effect. Such tubers frequently give rise to sprouts. In advanced cases aerial tubers are characteristic.

Considerable work has been done to determine the exact cause of this abnormal development, without evidence that it is of bacterial or virus origin. The best evidence supports the theory that it is of the nature of a toxin injected into the plant by the insect. This theory is strongly supported by the rather remarkable recovery shown by plants upon removal of the insect parasites.

Numerous tests are under way with a large series of possible controls with outstanding early results being shown from lime-sulfur applied as a spray. It shows a very definite lethal effect upon the insects and apparently has a positive residual effect in preventing the location of the small scale-like nymphs. Plants showing distinct psyllid yellow symptoms have after spraying shown almost complete recovery, as evidenced by a normal top growth and good tuber production. In an early field of the Irish Cobbler variety the checks produced at the rate of 51 bushels of marketable potatoes while a block receiving only one application of lime-sulfur, testing 33 degrees Baume, used at the rate of one gallon to 40 gallons of water, produced at the rate of 209 bushels of much better quality and size. In another field the check produced at the rate of 128.9 bushels and the sprayed portion 378.5.

Extensive tests are being carried on in the late-producing areas and several hundred acres have been sprayed by commercial producers. The early indications of results are promising. A more complete report will be made after the harvest.

GEORGE M. LIST
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WHERE DID THIS REALLY HAPPEN?

RECENTLY, in rereading Darwin's account of his journey around the world in the *Beagle*, I read in Chapter VII of an attack by a jaguar on priests in a church at Santa Fé, in the Argentine, a few years previous to his visit in October, 1833. Two priests were killed by the animal. When I read this I at once recalled that Seton, in "Lives of Game Animals" (Vol. I, pp. 28–29), quotes from Baird's "Mammals of the Mexican Boundary Survey" an account of a jaguar attacking and killing four people in the church of the convent of San Francisco, which it seems was situated on the Rio Grande 18 miles from Santa Fé! Seemingly, this convent is no longer in existence. This attack was on the tenth of April, 1825. I have looked up this account in Baird, and he apparently copied it from Kennerly's notes.

Knowing that Dr. Alexander Wetmore had been at the South American Santa Fé, I wrote to him, asking if he could tell me if there was a convent of San Francisco there, and he apparently took the trouble to ascertain for me that there is both a church and a convent of the San Franciscan Order at that place. A few years previous to 1833, the time of Darwin's visit to Santa Fé, could very well be 1825.

Baird's account is an abridged translation from the Spanish, and is prefaced by the following remarks:

> Many stories about the ferocity of this animal are told among the inhabitants of the western regions, but none substantiating the fact that a jaguar unprovoked will attack man. In the annals of the Convent of San Francisco, in Santa Fé, a bloody occurrence is recorded which contains some indication of the jaguar's nature.

Then follows the account.

Where did this attack actually take place? It would be strange, indeed, if two such attacks occurred at about the same time at places of the same name so widely separated as these two Santa Fés. Therefore,

the story of the attack must have been transferred from one Santa Fé to the other, but how and in which direction?

EDWARD R. WARREN

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A CHANGE OF NAMES

ON June 29, 1933, in the *American Museum Novitates* No. 638, I gave a preliminary description of an ancestral crocodile, naming it *Archaeosuchus richardsoni,* establishing the family Archaeosuchidae.

It has been called to my attention that *Archaeosuchus* is preoccupied (*Archaeosuchus cairncrossi,* Broom, R. 1905), and I take this occasion to rename this important Triassic reptile *Protosuchus richardsoni,* changing the family name to Protosuchidae.

BARNUM BROWN

DECEMBER 19, 1933

REPORTS

TRI-STATE GEOLOGICAL FIELD CONFERENCE OF THE UPPER MISSISSIPPI VALLEY

FIFTY-TWO geologists from the universities of Chicago, Illinois, Iowa and Wisconsin, Northwestern University, the State Geological Survey of Illinois and the Northern and Western Illinois State Teachers Colleges met at LaSalle, Illinois, on October 28 to organize the Tri-State Geological Field Conference of the Upper Mississippi Valley and participate in its first annual field trip. The tri-state conference is an outgrowth of a series of annual field trips that have been sponsored for some years past by the Illinois Geological Survey. As a result of suggestions made by Professor W. H. Twenhofel, of the University of Wisconsin, Dr. M. M. Leighton, chief of the Illinois State Geological Survey, issued special invitations to the geologists of Iowa and Wisconsin with the view of enlarging the scope of the field conferences and creating an opportunity for discussing and correlating current geological investigations that have common interest to the geologists of Illinois, Iowa and Wisconsin.

The two-day field trip was conducted by M. M. Leighton (glaciology), J. M. Weller (Pennsylvanian stratigraphy), H. B. Willman (physiography) and L. E. Workman (pre-Pennsylvanian stratigraphy) of the Illinois Geological Survey staff in the upper Illinois Valley between Starved Rock and the big bend. The Illinois Survey has recently completed a restudy of the geology along the Illinois River in preparation of a report on the geological resources adjacent to the new Illinois Waterway. This investigation in the Upper Illinois Valley was carried on by H. B. Willman.

Exposed near LaSalle are thick Pleistocene deposits, including tills, outwash and loess of various ages, 500 feet of Pennsylvanian beds, representing more than 12 cycles of deposition, and the Galena, St. Peter and Shakopee formations of the Ordovician system. In addition, 2,000 feet of older unexposed beds are known from well borings. The predominant structural feature in this part of Illinois is the LaSalle anticline, dipping steeply to the west and gently to the east. Folding occurred along this axis in pre-Pennsylvanian time as well as more recently and the Pennsylvanian beds overlie Middle Ordovician sediments with an angular unconformity which is the most important in the state.

On the morning of the 28th the conference proceeded eastward from LaSalle, and observed the LaSalle limestone rising sharply upon the west flank of the LaSalle anticline. This limestone is the thickest Pennsylvanian limestone in Illinois and near LaSalle furnishes the raw material for three large Portland cement plants. After reaching the crest of the anticline the route of the party extended for several miles upon an upland bedrock surface that was swept by the Kankakee torrent in the Carey substage of Wisconsin age. The preexisting valley was inadequate to accommodate the large volume of water derived at this time from the rapidly melting Lake Michigan and Saginaw glacial lobes, the glacial Kankakee River overflowed, and previously deposited glacial materials were swept from the bedrock surface. East of LaSalle this surface is formed by the Galena dolomite, St. Peter sandstone and Shakopee dolomite. It is rendered uneven by scoured undrained depressions and gravel bars and is an example of scab-land topography on a small scale mantled by soil. Near Utica the Shakopee dolomite has been used in the manufacture of hydraulic cement, and some of the old abandoned mine entrances were seen in the north bluff of the Illinois, where this variable formation is well exposed on the crest of the LaSalle anticline.

At Utica the conference turned southward, crossed the Illinois River and proceeded to Starved Rock State Park for luncheon. Starved Rock is a precipitously sided remnant of St. Peter sandstone, rising more than 100 feet above the flood plain of the Illinois, that was separated from the south valley wall by the Kankakee torrent. From its top, which is less than an acre in extent, a magnificent view of the Illinois valley may be obtained.

The afternoon was devoted to the study of four Pennsylvanian sections in the bluffs of the deeply

intrenched Vermilion River between Streator and Oglesby. In northern Illinois the Pennsylvanian cyclothems[1] are not normally developed. Here marine deposition predominated more than in any other part of Illinois, and the non-marine sandstones, that elsewhere are the basal members of most cyclothems, are thin or absent with the single exception of the Vermilionville sandstone, which locally attains a thickness of 100 feet or more. Four coals have been mined in this district, Nos. 2, 6, 7 and another, the Streator coal, which occurs between the horizons of Nos. 5 and 6. Coals Nos. 2 and 7 are persistent uniform beds. Coal No. 6 is missing throughout wide areas, but here and there it occurs in lenticular bodies a few miles in extent and achieves a maximum thickness of 8½ feet. The Streator coal is abnormal in that it occurs in the midst of a sandstone succession, does not have an underclay and is not overlain by marine beds. At some places it is very shaly and impure, and this seam, which occurs in irregular lenticular pockets, may be an example of a transported coal. Coals No. 4, the Harrisburg "No. 5" coal of southern Illinois, and No. 5, the Springfield coal, are entirely absent from the LaSalle area, although their horizons are plainly shown by underclays directly succeeded by marine strata.

The first section visited is at the southeastern extremity of the Marquette Cement Company's quarry on the north side of Vermilion River. Here is an excellent exposure of the LaSalle limestone and the next overlying cyclothem, which consists of a thin discontinuous basal sandstone, an underclay, a thin coal and overlying marine shales and limestones. Near Lowell one of the finest cut-bank sections in Illinois was seen rising nearly 100 feet above the river, extending from Coal No. 2 to the Vermilionville sandstone and including the barren horizons of Coals Nos. 4 and 5. A short distance to the east the river flows on dipping beds of Galena dolomite. The interval between this formation and Coal No. 2 is occupied by a thick complex underclay succession, which, in western Illinois, expands and is divisible into 12 cyclothems. Near Lowell this underclay furnishes material for the manufacture of high-grade face brick. At Klein Bridge a section was examined extending from the marine beds above Coal No. 6 to the base of the Vermilionville sandstone, including the horizon of the Streator coal that is here represented by black canneloid shale. A lenticular mass of gray shale locally intervenes between Coal No. 6 and its black roof shale, causing the latter to rise abruptly above the coal. At Bailey Falls the Vermilion River flows through a narrow gorge cut beneath the resistant LaSalle limestone, that rises steeply to the east on the flank of the anticline. Nearly 70 feet above the present river level a pot-hole 10 feet deep and 2½ feet in diameter, that was probably formed by the flood waters of the Kankakee torrent before the modern gorge was eroded, is preserved in the limestone.

[1] Strata deposited during a single cycle of deposition.

At an evening meeting short talks were given by L. E. Workman, on the subsurface geology of the LaSalle area; A. H. Bell, on magnetometer investigations along the LaSalle anticline; J. M. Weller, on Pennsylvanian sedimentation in northern Illinois; and H. B. Willman, on the Pleistocene history of the Upper Illinois Valley. After discussions of various geologic problems suggested by these talks the Tri-State Field Conference of the Upper Mississippi Valley was organized. Selected to serve as an executive committee were M. M. Leighton, Illinois Geological Survey, A. C. Trowbridge, University of Iowa, and W. H. Twenhofel, University of Wisconsin. It was decided that the 1934 conference should be held in Wisconsin under the direction of Professor Twenhofel, who will serve as chairman of the executive committee for the next meeting.

On the morning of the 29th the party proceeded eastward to Split Rock, where strongly dipping St. Peter sandstone is overlain by Lower Pennsylvanian beds that dip only about half as steeply. The route was then retraced to LaSalle and thence the conference continued west to Spring Valley, where a large gravel pit shows excellent sections of a gravel delta nearly 60 feet thick that was deposited in a preexisting tributary of the Illinois River flooded by backwater from glacial Lake Illinois. This delta is believed to have been mainly formed during two seasons of melting, when the glacial front stood only a very short distance to the east. The occurrence of this and other similar deltas proves that the upper Illinois valley, with some of its major tributaries, was in existence before Wisconsin time. There is, however, no evidence indicating that this part of the valley antedates the Illinoian glacial invasion, and it is therefore believed that the upper Illinois valley originated after the retreat of the Illinoian ice sheet. The narrow upper Illinois valley is in strong contrast to the wide valley below the big bend which marks the course of the pre-glacial Mississippi River.

The next locality studied west of Hicks Corners shows an excellent section extending from the LaSalle limestone downward through the subjacent cyclothem and including the upper beds of the next lower cyclothem. Except for the thin coal below the LaSalle limestone and the underclays in this and the lower cyclothem, the section consists exclusively of marine beds. The LaSalle limestone here is much more argillaceous and impure than it is only a few miles farther to the east.

Significant Pleistocene sections were seen in a highway cut west of Depue and in cut banks on East

Bureau Creek 5 miles to the northwest. The first section shows Tazewell loess above Bloomington drift. The profile of weathering of the loess extends only slightly into the underlying drift. The other sections consist, in descending order, of Wisconsin till, Iowan loess, late Sangamon loess, Illinoian gumbotil and Illinoian drift. The Iowan loess is entirely unweathered, but the late Sangamon loess is leached throughout. Peat occurs in the lower part of the Iowan loess and in the Sangamon loess. Outside the borders of the Wisconsin drift sheet the Tazewell and Iowan loesses combine to form the so-called Peorian loess of western Illinois and Iowa. These phenomena emphasize the intimate relationships of the Iowan and Wisconsin drifts and have resulted in the recent reclassifications of the Pleistocene, in which the Iowan and Wisconsin drifts and associated deposits are combined with the Recent to form the Eldoran series.

At noon the conference adjourned.

J. MARVIN WELLER

URBANA, ILLINOIS

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW METHOD OF ILLUSTRATION

CLEAR and carefully chosen illustrations make for speed and ease of comprehension and thereby increase the value of geological articles. With the foregoing aim in view, the writer used the following method of illustrating a thesis dealing with joints in sedimentary rocks.

The field work was done in the Black River Valley region of New York State, where the thin bedding of the Ordovician strata and the close spacing of the approximately vertical joints made possible the collection of "joint blocks"—rock specimens, two of whose sides are normally bedding plane surfaces and the other sides joint plane surfaces. Care was exercised to obtain blocks with joint plane directions which represented the dominant strikes of the area from which they were taken. As each block was collected, the directions of the joint planes bounding it were carefully ascertained with a Brunton pocket transit and recorded on the block. The writer used a colored pencil for noting the directions, and it worked well on the smooth bedding plane surfaces. For rough surfaces, adhesive tape marked with ink would no doubt prove a better method.

In the laboratory, each joint block was brushed free of dust and loose particles and a six-inch white celluloid scale attached to the face by means of rubber cement. The specimen was then set up against a black background and photographed with a Vogtlander camera.

The use of the black background prevented halation and made possible a longer exposure to bring out details. Also, a black background, which on the negative would be light, made it possible to use opaque for printing and orienting the block on the negative.

The negatives were first coated with retouching fluid. Opaque, which is thick and must be thinned to proper consistency, for pen use, was then applied. The direction of each joint plane was printed parallel to the strike of the plane. A north-south arrow was drawn in the correct direction, after which the negative was squared with reference to the arrow. The negatives were printed in the usual manner, using No. 3 Velox paper.

In the resulting pictures, the strike relationships of the various joint sets were clearly evident. It is the opinion of the writer that a better presentation and conception of the facts was attained in this way, than if the directions of the joint strikes had been merely diagrammed.

MARJORIE HOOKER

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A SIMPLE METHOD FOR MEASURING SMALL TIME INTERVALS

IN many physiological laboratories it is inexpedient to supply each student with an electrically maintained tuning fork to measure small time intervals in nerve and muscle experiments. A dependable and simple arrangement has been in use here for some time where an accurate record of fractions of a second is required. The only conditions necessary are that the laboratory should be supplied with A.C. current from the mains, and the frequency of the current should be known.

The materials needed are a small signal magnet with a light flexible steel vibrator, a lamp socket, a 50 or 60 watt lamp, a push button or switch and a plug. The adjusting screw is removed from the signal magnet so that the vibrator is suspended free above the electromagnet. The coil of the magnet is connected in series with a lamp (as resistance) and a switch, and the circuit is completed by connecting across the mains. When the current is switched on, the vibrator is drawn towards the magnet and vibrates above it at double the frequency of the alternations in the mains. If the pointer of the signal is allowed to record lightly on a revolving kymograph drum, it will draw a series of waves of sufficient amplitude to serve as a time record. The peaks of the waves correspond to the alternate positive and negative surges

in the line, so that the distance between two adjacent peaks corresponds to the time occupied by half an alternation. The wave may be slightly altered in form and amplitude by trying different signals and by altering the wattage of the lamp in circuit, but care must be taken not to burn out the coil.

In Medford, Mass., the local current is 110 v. 60 cycle A.C.; thus the distance between two peaks corresponds to a time interval of 1/120 second. The rate of alternation in A.C. current is very constant, and the above arrangement has been found very satisfactory, particularly for student use. It is accurate and simple and requires no attention or delicate adjustment.

K. D. ROEDER

TUFTS COLLEGE

SPECIAL ARTICLES

CONTRASTING PROPERTIES OF IONS, ZWITTERIONS AND UNCHARGED MOLECULES[1]

Apparent molal volume: The great density of such constituents of biological systems as amino-acids and most proteins depends largely upon the electrical charges borne by these molecules. Molecules can not be said to exist in the inorganic crystal, where each ion is related to all others surrounding it. By contrast the distances separating atoms within molecules of an uncharged organic crystal are far smaller than those between atoms of adjacent molecules.[2] Intermediate in behavior are the zwitterions recognized by Bjerrum[3] just a decade ago as being neither electrolytes nor uncharged molecules. Of great importance in physiology and morphology these charged molecules are closely packed and the density of the smallest of them, glycine, is 1.61 in the solid state.

The densities not only of amino-acids, but of certain proteins[4] appear to be greater in dilute solution than in the solid state. This results from electrostriction of the solvent, estimated to be approximately ten cc per mole per charge when these are widely separated from each other.[5] Electrostrictions of this magnitude are produced by ions slightly greater in radius than 2 Å. The smallest of the zwitterions, glycine, has a radius of 2.8 Å. When the positive $-NH_3^+$ group is separated from the COO^- group by only one carbon atom, as in all neutral α amino-acids, the combined electrostrictive effect is reduced to 13.4 cc per mole.[6]

Influence of concentration upon apparent molal volume: Not only the closeness of approach of charged groups in the same molecule, but increase in concentration of the solution increase the apparent molal volume. This increase has been shown to be proportional to the square root of the concentration for salts, and also for cane sugar and urea,[7,8] though these molecules do not bear electrical charges, as may be demonstrated from the density of their solutions.[6] That the square root law holds for the latter substances[9] because of the polarity of the hydroxyl and amino groups is strongly suggested by study of aliphatic acids containing various substituents. Acetic acid does not obey the square root law, and increasing the length of the hydrocarbon chain, as in propionic, butyric and valeric acids, increases the deviation from linearity. Chloracetic acid, in which the strongly electronegative chlorine atom is substituted for a hydrogen atom, does, however, obey this law, as do di- and trichloracetic acids ($\frac{\delta\Phi}{\delta\sqrt{c}} = 1.55$, 3.12, 6.00). Substituents which increase electrolytic dissociation appear also to increase the proportionality constant ($\frac{\delta\Phi}{\delta\sqrt{c}}$) relating the apparent molal volume to the square root of the concentration.

Glycine, which contains the electronegative amino group, obeys the square root law and so do its hydrochloride and sodium salts ($\frac{\delta\Phi}{\delta\sqrt{c}} = 1.52$, 2.54, 3.89). Neither amino-acids of long hydrocarbon chains nor their hydrochlorides or sodium salts obey this law, however, but behave in this respect rather like aliphatic acids. The salts of amino-acids as of aliphatic acids must, however, be considered largely dissociated in solution. Thus the square root law appears to depend largely upon the polarity of the groups in the molecule.

The apparent molal volume of β alanine increases approximately with the first power of the concentration rather than with its square root. This is also true of glycyl-glycine, which contains the polar amide linkage, and of the sodium salt of ε amino caproic

[1] Abstract of paper read at the meeting of the National Academy of Sciences in Cambridge, November 22, 1933.

[2] S. B. Hendricks, *Chem. Rev.*, 7: 431, 1930.

[3] N. Bjerrum, *Z. Physik. Chem.*, 104: 147, 1923.

[4] H. Chick and C. J. Martin, *Biochem. Jour.*, 7: 92, 1913.

[5] H. H. Weber, *Biochem. Z.*, 218: 1, 1930.

[6] E. J. Cohn, T. L. McMeekin, J. T. Edsall and M. H. Blanchard, *Jour. Biol. Chem.*, 100, Proc. xxviii, 1933.

[7] W. Geffcken, *Z. Physik. Chem.*, 155: 1, 1931.

[8] F. T. Gucker, *Chem. Rev.*, 13: 111, 1933.

[9] The melting points of cane sugar (186° C.) and of urea (133° C.) are also higher than those of most uncharged molecules. The amino-acids melt in the neighborhood of 300° C. and neutral salts at still higher temperatures.

acid. The sodium salt of glycyl-glycine behaves in a manner intermediate between the sodium salt of glycine and of ε amino caproic acid. Despite its large dipole moment, the apparent molal volume of isoelectric ε amino caproic acid, with its long hydrocarbon chain, changes very little indeed in solutions containing less than 25 per cent. of amino-acid. This type of behavior is also characteristic of most proteins, whose great apparent density in solution diminishes but little even in the concentrations which obtain in biological systems.

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"EXERGIC" AND "ENDERGIC" REACTIONS[1]

IN the consideration of chemical reactions it is often necessary to distinguish between (a) those processes which occur spontaneously, for example, in a primary cell, that is, which are capable of doing work; and (b) those which require work to be done in order to bring them about, for example, the electrolytic decomposition of water into hydrogen and oxygen. Thermodynamically, these types of reaction are distinguished as resulting in (a) a decrease in free energy and (b) an increase in free energy.

It is proposed to designate these two types of reaction respectively as (a) "exergic," that is, capable of giving out work; and (b) "endergic," that is, taking in work. They are derived from the Greek root "ergon," work.

At first it might appear that the need for such terms is met by the customary expressions "exothermic" and "endothermic." It has long been known, however, that these terms are inadequate to describe chemical reactions, and hence the concept of free energies was introduced. As above noted, the new terms apply to the free energy and not to the total energy of the process. The majority of reactions that are exothermic are also exergic, and most of those that are endothermic are endergic, but the relation is not universal.

Thus, Lewis and Randall[2] cite a cell in which the reaction

$$Ag(s) + HgCl(s) = AgCl(s) + Hg(l)$$

yields at 298° K a potential of 0.0455 V (that is, according to the above definition the process is exergic), although the chemical reaction is endothermic, with a total heat change, $\triangle H_{298}$, equal to +1280 cal. In order for the cell reaction to occur spontaneously, heat must be taken from the surroundings.

Similarly, it follows that the reverse reaction

$$Hg(l) + AgCl(s) = Ag(s) + HgCl(s)$$

is exothermic, that is, $\triangle H_{298} = -1280$ cal.; but in order for this process to occur in a cell, work equivalent to 0.0455 V must be done upon it, that is, the process is endergic.

The need for such terms was evidently felt by H. J. Creighton,[3] who states that chemical changes "are called 'exo-electrical' when they develop electrical energy and 'endo-electrical' when they absorb electrical energy." His terms have much the same meaning as those now proposed, but are somewhat less general in their application.

No new concepts are involved in the proposed terms. Justification for their use must be found in their conciseness or pedagogic convenience. The proposed definitions are as follows:

"Exergic reactions are those which occur with a decrease in free energy."

"Endergic reactions are those which occur with an increase in free energy."

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[1] Publication approved by the director of the U. S. Bureau of Standards.

[2] "Thermodynamics," p. 174. McGraw Hill Book Co., New York, 1923.

[3] "Principles and Applications of Electrochemistry," Vol. 1, 2nd ed., p. 8. John Wiley and Sons, New York, 1928.

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